KEYWORDS

Industry
Capital goods
Industrial development
Competitiveness
Productivity
Exports
Imports
Value
Industrial statistics
Development indicators
Brazil

The structure and competitiveness of the Brazilian capital goods industry

André Nassif

This article analyses changes in the structure and competitiveness of the Brazilian capital goods industry since the early 1990s and proposes a classification within that industry based on the different industrial segments from which the demand for machinery and equipment derives. Although this industry still accounts for a large share of manufacturing sector value added, the production efficiency and international competitiveness of the segments it comprises are quite heterogeneous. The article singles out the segments with the greatest development potential and suggests measures that could be taken in each of them to complement the industrial and technology policy instruments contained in the Production Development Policy officially established in May 2008.

André Nassif
Economist with the Planning Area of the National Bank for Economic and Social Development (BNDES), Brazil
andrenassif@bndes.gov.br

I
Introduction

A country's capital goods industry must count among the engines of its economic development. Both microeconomically and macroeconomically, the importance of this industry as a creator of production capacity and a driver of technical progress in the economic system generally is well recognized, even when the country is a net importer of these goods. Indeed, its linkages with the science and technology base and its role in spreading technological externalities and embodying innovations in the goods it manufactures make it in some degree responsible for the systemic competitiveness of the economy.[1] It is not surprising, then, that the capital goods sector was one of the four priority sectors identified in the Industrial, Technological and Foreign Trade Policy (PITCE) applied during President Luiz Inácio Lula da Silva's first term (2003-2006).

The new industrial, technological and foreign trade policy introduced in President Luiz Inácio Lula da Silva's second term (2007-2010) and officially announced in May 2008 as the Production Development Policy (PDP) is much further-reaching and more ambitious than its predecessor. To promote technological training, encourage innovation and stimulate exports, the PDP provides fiscal, tax and credit incentives to 24 sectors deemed to be of high priority. Despite its apparent sectoral focus, the new policy has been designed from a systemic perspective and the intention is to use target-setting and government follow-up to ensure that the industries thus encouraged create positive externalities for the economic system as a whole. In the PDP, the capital goods industry is once again identified as a priority recipient of public-sector incentives to enhance the competitiveness of the Brazilian economy.[2]

This article sets out to use domestic and international competitiveness indicators to analyse the development potential of the Brazilian capital goods industry subsequent to trade liberalization. Its main objective is to identify the segments with the highest levels of current and potential competitiveness. Given the diversity and complexity of the capital goods sector, it also seeks to identify the segments with the best prospects of meeting Production Development Policy goals, particularly those that relate to increasing domestic productivity, expanding and diversifying exports and furthering the country's economic and social development.[3]

The article contains six sections, including this introduction. Section II sets out the theoretical framework for the analysis and describes the classification that will be used here to delimit the capital goods industry. Section III briefly summarizes the historical development of the capital goods sector in Brazil, before and immediately after the trade liberalization of 1990. Section IV presents the main empirical evidence on the competitiveness of the Brazilian capital goods industry, using national and international performance indicators for the 1989-2006 period. Section V discusses some support measures to supplement the industrial and technological policy instruments contained in the Production Development Programme for each of the segments with the greatest development potential in Brazil. Section VI, lastly, sets forth some brief conclusions.

☐ Research assistance for this paper was provided by Daniel da Silva Grimaldi, Thiago Lopes Cantalice and Júlia Ferreira Torracca. A preliminary version was published as a discussion paper by the National Bank for Economic and Social Development (BNDES). That preliminary version was greatly improved upon by the input of Fernando Pimentel Puga, Mário Cordeiro de Carvalho Jr., Mário Luiz Possas, Cláudio Leal, Márcio Nobre Migon, João Carlos Ferraz, Yolanda Ramalho, Roberto de Oliveira Pereira, Cláudia Nessi Zonenschain and the other participants in the internal seminar held by the BNDES Planning Department. This final version has been enhanced by the suggestions of two external referees. Any remaining errors are the author's alone.

[1] The term "systemic competitiveness" is a reference to Porter (1991). Fajnzylber (1988) used the term "spurious competitiveness" to refer to "a country's capacity to sustain and expand its share of international markets (…) by making use of the available cheap manpower and of subsidized lines of credit", in contrast to "genuine competitiveness", which is based on "improved productivity resulting from the incorporation of technological advances" (pp. 12-13). In this author's view, "spurious competitiveness" is not sustainable in the long run.

[2] Full details of the PITCE and PDP are available online on the website of the Ministry of Development, Industry and Commerce (http://www.mdic.gov.br).

[3] The Production Development Policy provides public-sector incentives for mass-produced and made-to-order capital goods, but does not establish which segments have the best prospects of achieving the new industrial policy goals.

II

The capital goods sector: theoretical framework and proposed typology

This section describes the theoretical framework surrounding the competitiveness indicators used in this article. It has become commonplace to assert that the capital goods industry plays a strategic role in countries' economic development because it produces the machinery and equipment used by the entire production system, embodies new technology endogenously and, consequently, spreads technical progress to the rest of the economy. Countries that succeed in internalizing the production of certain kinds of more sophisticated capital goods in an economically efficient way tend to enhance their technological independence and economic development potential. In other words, the capital goods industry, allied with other factors, strongly influences productivity growth and competitiveness in the economy as a whole.

The concept of competitiveness has been the subject of fierce debate in the economic literature, since the factors determining it depend on the hypotheses underlying the theoretical methodology. According to the neoclassical approach, for example, competitiveness is clearly linked to cost efficiency, which is a biunivocal function of the behaviour of productivity.[4] Conversely, the neo-Schumpeterian approach treats competitiveness as a dynamic, complex and uncertain process deriving from the efforts of companies to innovate in quest of more lucrative opportunities or a larger share of the market or markets in which they operate.[5] Although it is not our intention to pursue this debate here, there can be no doubt that the capital goods industry makes an essential contribution to increased long-run productivity and competitiveness in the economy.[6]

According to theoretical and empirical studies of long-run economic growth determinants, technical progress (i.e., the spillover not directly observable in the data) can derive from two sources: technologies embodied in capital goods investments and "disembodied" technologies resulting from the know-how built up in research and development (R&D) activities, workforce education and training and other residual forms of human capital.

According to empirical evidence based on growth accounting methods, capital goods-embodied technologies contributed more to productivity growth in the United States during the post-war period than disembodied technologies. In the 1954-1990 period, about 58% of the rise in productivity was due to the former and 42% to the latter (Greenwood, Hercowitz and Krusell, 1997, p. 351). In a shorter period (1966-1989), stripping out the adverse effects of the business cycle, Abramovitz (1993) obtained lower but still considerable results, with figures of 46% and 54%, respectively.

It is a fact that the contribution of capital goods investment to rising productivity underwent a relative decline in the twentieth century, since prior to that, in the 1855-1890 period, it had come to account for some 66% of that growth, according to estimates by Abramovitz (1993, p. 223). Nonetheless, the same author argues that the lessening of the relative contribution of capital goods as a source of technological progress since the mid-1960s is only apparent. The estimated coefficients of the variables accounting for productivity improvements do not reveal the mutually reinforcing and interdependent relationship between tangible and intangible capital accumulation and technological progress (via the embodiment of technology, investment in R&D, learning by doing and using, education and other methods). In a word, in the most recent period the technology spillover effect has been manifested in

[4] See Koutsoyiannis (1975) and Kreps (1990).

[5] See Nelson and Winter (1982) and a study of the subject in Possas (1996).

[6] The well-known criticism by Krugman (1994) of the concept of competitiveness as applied to countries is only partially valid. The primary sources of competitiveness (and economic growth itself) are indeed to be sought in firms, where crucial decisions about investment and innovation in processes, products and organizational methods are taken. However, competitiveness needs to be seen as a dynamic process, one that entails interaction between firms, markets and other public and private institutions but that has implications for international political and economic relations.

a marked dependency between the use of more sophisticated equipment and other forms of human capital.[7] [8]

The importance given to the capital goods industry is justified by a number of other considerations. Apart from the technological arguments, it plays an undeniably important role in expanding potential production capacity and, consequently, in sustaining long-run capital accumulation and economic growth. Furthermore, as Greenwood, Hercowitz and Krusell (1997, pp. 345-346) point out, technological changes embodied in investment can increase potential supply only if preceded by fixed-capital investments, whereas this is not a condition for change induced by the neutral part of technology.

It needs to be asked whether capital goods might contribute in the same way to long-run productivity growth and systemic competitiveness if they were imported. In the long run, the answer is no. Developing countries do not need to master all segments (and nor should they try). However, the empirical evidence does confirm that the forms of technological change manifested in greater capital-intensity (i.e., those embodied in equipment) have a common characteristic: they are specific to the production of equipment and not the demand for it (Greenwood, Hercowitz and Krusell, 1997, p. 345). Using a microdata model based on a dynamic cost function, Paul and Siegel (1999) also confirm that in the manufacturing sector, owing to the existence of various industries (among them the capital goods industry) with technologies subject to increasing returns to scale, industrial groupings arising as a result of dynamic supply-side effects are more in evidence than those deriving from demand.

In the particular case of the capital goods industry in developing countries, traditional segments operating in industrial plants that use standardized technologies and produce on a relatively small scale coexist with capital-intensive segments operating in industrial plants characterized by technological indivisibilities and huge economies of scale. This is indicative of a high degree of structural heterogeneity within this industry. This heterogeneity is manifested, for example, in firm size, ownership and corporate structures, the share of each segment in the industry's total value added, the rate of productivity growth, the strategies used to bring their technology closer to the international frontier (and the results obtained by these) and their export potential.

Thus, competitiveness is largely determined by the production and technology structure of each segment of the industry. In the segments where the technologies used are widely available and product cycles are long, barriers to entry are usually low, which makes it possible for small, medium-sized and large enterprises to coexist. Conversely, in segments where technologies are characterized by indivisibilities and unit costs can only be kept down by ensuring that production levels match the minimum efficient scale, highly concentrated industrial structures (due to enormous barriers to entry) are ultimately more conducive to competitiveness.

Regarding particular strategic options for firms producing capital goods, there is no consensus as to whether these have positive or negative effects on their competitive positioning. The options most discussed include greater product specialization or diversification and vertical or horizontal integration of production. In both cases, firms will have to weigh up the advantages and disadvantages and make their own decisions with reference to structural trends in their industry in the relevant historical context.

In the first case, for example, increased global competition has led to greater specialization by firms in the sector. According to Vermulm and Erber (2002, p. 29), when firms opt to reduce the number of products on their production lines they lose some of the economies of scope that derive from greater variety, but swell the net profits from economies of specialization. Kupfer (1994) argues that this has been the international trend (at least in the machinery and equipment segment), so that greater specialization in specific market niches has created opportunities for small and medium-sized enterprises that have technological expertise and establish technical assistance networks for customers.

In the second case, theoretical studies of industrial organization have not explained whether greater production efficiency is also associated with greater commitment by firms to a horizontal

[7] Nelson (1964) pointed out some time ago that technological advance does not significantly reduce the contribution of "embodied technologies", the reason being that as a rising investment rate (which accompanies technological advance) modernizes the capital stock (i.e., the age of equipment falls), the contribution of the technology embodied in machinery and equipment tends to rise.

[8] We also need to be aware of the difficulties of calculating the contribution deriving from human capital as such. As Griliches (1994, p. 16) points out, knowledge cannot be measured in the same way as iron ore reserves since, unlike these, it manifests itself as a constant flow of very heterogeneous information.

production integration strategy, which basically consists in outsourcing the production of some or all of the raw materials and other inputs needed to manufacture a particular product. As Scherer and Ross (1990) argue, firms tend to backtrack on vertical integration when they calculate that efficiency would be improved by a greater division of labour. Nonetheless, it is possible that the prevailing pattern of competition in the industry, the distance and transport costs involved in obtaining raw materials, the structure of sectoral protection, the structure of sales taxes, the level of sectoral regulation and other factors may lead firms to seek greater efficiency by following a strategy contrary to the one described (Tirole, 1995, p. 17). According to Scherer and Ross (1990, p. 94), *cost-cutting is the main reason for firms to pursue greater vertical integration*. In this respect, the empirical evidence available on changes in the degree of vertical integration in the United States economy have not revealed any long-term trend. Between the late nineteenth century and the early 1980s (unmistakably a period of technological and structural change in that economy), developments within the industry did not evince any explicit trend towards greater or lesser vertical integration.[9]

The capital goods industry is generally regarded as the one most directly affected by the business cycle. Faced with a large drop in the demand for its products during prolonged periods of recession, capital goods firms tend to operate with higher levels of idle capacity than the average for the whole economy, which makes considerable inroads into their competitiveness. In the case of capital-intensive segments, the loss of economic efficiency is compounded by the average increase in fixed production costs. This suggests that, as in other sectors of economic activity, the competitiveness of the capital goods industry depends on both microeconomic and macroeconomic factors, but that it tends to be more acutely affected than other sectors of the economy by the latter.

In the specific case of the effect of the real exchange rate on the economic efficiency of production sectors in general and the capital goods industry in particular, the predictions of theoretical studies are ambiguous: on the one hand, an overvalued real exchange rate can stimulate productivity by reducing the relative price of imported equipment and inputs; on the other, an undervalued real exchange rate can also help to increase efficiency via the reallocation of economic resources to tradable goods segments or sectors, particularly those in which the country has a potential comparative advantage.

Given the range and diversity of the capital goods industry, and its technological variety and complexity, no country could master a large number of its segments (and nor would this be advisable).[10] Again, even in countries that have managed to develop more technologically complex segments in this industry, the import tariffs set have been moderate or low, so that domestic production growth has generally been accompanied by a substantial increase in the flow of imports.[11] More recently, as comparative advantage has been secured in a limited number of segments, international trade in capital goods-producing countries has begun to be characterized by large volumes of intra-industry trade.

Different typologies can also be established to reflect the complexity of the capital goods industry by categorizing the variety of products in specific segments of this industry, either by the technology content of products or by the purposes they are designed for. The traditional classification is based on technological complexity and divides the industry into two categories: (i) segments producing capital goods to order, which have high product engineering R&D costs because they are more technologically sophisticated and are designed to meet users' specific needs, and (ii) segments mass-producing standardized capital goods, production of which is subject to large static economies of scale and, with rare exceptions, demands not only quite high minimum efficient scales but also hefty process engineering R&D expenditure.[12]

Since the object of this paper is to analyse the national and international competitiveness of the capital goods industry to identify the segments with the greatest development potential, the most suitable classification is one that categorizes machinery and

[9] See Scherer and Ross (1990, p. 96).

[10] The recent introduction of electronics into the mechanical and electrical capital goods segments has in some cases broken down the traditional division between industries producing mechanical and electrical capital goods, on the one hand, and electronic capital goods, on the other. See Vermulm and Erber (2002).

[11] See Amsden (1989) on the Republic of Korea and Amsden (2001) for a comparative analysis of developments in Asia and the Latin American countries.

[12] See Vermulm (1993).

equipment production by the business segments that are the end users. This classification is compatible with the argument made by Nelson (1996) that know-how built up through learning by using machinery and equipment stimulates and promotes the introduction of new technical advances by both users and suppliers of capital goods. Thus, it is possible to analyse the performance of machinery and equipment segments oriented towards activities with different levels of technology content. The classification used in this paper adapts the segments in the National Classification of Economic Activities (CNAE) of the Brazilian Geographical and Statistical Institute (IBGE) as follows: traditional industrial machinery and equipment, electricity generating machinery and equipment, telecommunications machinery and equipment, electronic and non-electronic office machinery and equipment, medical and hospital equipment, agricultural machinery and equipment and transport machinery and equipment.[13]

III

The capital goods sector in Brazil before and immediately after trade liberalization

The Brazilian capital goods industry dates back to the late nineteenth century. By contrast with the industries of a number of late-industrializing European countries, it arose spontaneously and without deliberate State support. During the main period of what is known as the primary-export stage (1870-1930), the industry produced capital goods that were fairly rudimentary by the standards of the time, usually designed for activities associated with coffee production and commercialization.[14] Although the effects of the crisis that began in 1929 led to the breakdown of the primary-export model and contributed to the emergence, again spontaneous, of the import substitution industrialization model, the lack of a national plan for the development of this industry goes some way towards explaining why the capital goods sector continued to be technologically backward in Brazil until the late 1940s.

From the mid-1950s onward, the Brazilian industry was aided by a number of government incentives, including a customs protection scheme and a system of differentiated exchange rates. Once the adverse effects of economic stagnation in the 1960s had been overcome –the capital goods industry grew at negative average annual rates (-2.6%) between 1962 and 1967– the sector once again began to display considerable internal dynamism in the early 1970s.[15] In the first half of that decade, gross fixed capital formation in the Brazilian economy averaged 20.2% of the country's gross domestic product (GDP), boosting machinery and equipment production.[16] In the second half, the capital goods industry, classified as one of the priority industries in the second National Development Plan (1974-1979), benefited from a series of public-sector incentives, such as government procurement policy, agreements mandating ever-increasing shares of national content by value in major State-financed investment projects, and the programme of the Commission for the Concession of Fiscal Benefits to Special Export Programmes (BEFIEX) exempting firms that undertook to make high-value exports in future from capital goods import taxes.[17] The data available show that growth in this industry's gross output by value averaged 20% a year between 1970 and 1977.[18]

However, only a few segments of the capital goods industry were able to move towards technological convergence and attain economic efficiency levels compatible with the latest advances in the world

[13] In the two-digit cnae, manufacturing industry contains 24 divisions (from number 10 to number 33). The data on different machinery- and equipment-producing segments used in this research, which is based on the three-digit CNAE, were taken from divisions 26, 27, 28, 29, 30 and 33. See the IBGE website (http://www.ibge.gov.br) for further details.

[14] See Silva (1982).

[15] See Vermulm (1993, p. 2).

[16] Data from Ipeadata, a database of the Institute of Applied Economic Research (IPEA), available at http//www.ipea.gov.br.

[17] See Nassif (1995) for further details.

[18] See Vermulm (1993, p. 2).

market.[19] In those segments whose technology was subject to increasing returns to scale, a large proportion of firms were operating at production levels below the minimum efficient scale. Furthermore, impelled by severe tariff and non-tariff constraints on importing, these firms went too far with the vertical integration of production.[20]

Again, despite the ambiguities inherent in the logic of the industrial policy contained in the second National Development Plan (1974-1979), which combined a high degree of tariff and non-tariff protection with public subsidies to encourage local production, while at the same time seeking to lower domestic investment costs by applying fiscal and tax cuts or breaks to external purchases of capital goods, the predominant style of growth in the demand for capital goods imports was one whereby its expansion complemented domestic production, owing to the rise in the national investment rate during cyclical upturns in the economy (Resende and Anderson, 1999, p. 17).[21]

This overblown protection for local industry would end only with the trade liberalization process of 1990-1994. Among the main repercussions of this reform in the capital goods sector was a sharp rise in the import ratio,[22] the rapid exit of inefficient firms from the market,[23] a substantial reduction in the range of goods produced per company, a slow reversal in the vertical integration of production processes[24] and rapid internationalization of the industry.[25]

IV

The competitiveness of the Brazilian capital goods industry after trade liberalization: empirical evidence

This section will analyse the data available on the performance and on the domestic and international competitiveness of the capital goods industry. Given that the methodologies of the IBGE Annual Industrial Survey (PIA) before and after 1996 are incompatible, it was only possible to analyse industrial production indicators in the 1996-2005 period (2005 being the last year available from the PIA at the time this research was conducted). Most of the external trade indicators are for 1989-2006; the data concerned were obtained from the Foreign Trade Department (SECEX). The codes of the old Brazilian Merchandise Nomenclature (NBM) had to be converted to those of the current MERCOSUR Common Nomenclature (NCM) and from this to the CNAE codes.[26]

[19] The estimates of Kume, Piani and de Souza (2000) show that the machinery and equipment sector recorded effective protection rates of 44% in 1989, a little lower than the average for the whole economy, which was 46.5%. These data confirm that the trade reform which took place in 1988, and whose main thrust was the lowering of import tariffs, did not do much to reduce effective protection in the economy, given the prevalence of high non-tariff barriers. For this reason, it is in 1990 that effective trade liberalization should be considered to have taken place in Brazil, as gradual but deep cuts in customs tariffs were combined with the abolition of most non-tariff restrictions. See Nassif (1995 and 2003a).

[20] See Vermulm and Erber (2002).

[21] Resende and Anderson (1999, p. 17) state that until the late 1980s, increases in the capital goods import ratio occurred when both the quantum of such goods imported and the quantum produced rose, confirming that demand for imports and the behaviour of domestic production were complementary.

[22] Moreira and Correa (1996) state that the import ratio as a proportion of apparent consumption (output plus imports minus exports) rose from 20.6% in 1990 to 45.9% in 1995.

[23] Vermulm (1993) and Vermulm and Erber (2002).

[24] Vermulm (1993), Miranda (2001) and Vermulm and Erber (2002). These authors suggest but do not empirically demonstrate the supposed rolling back of vertical integration.

[25] Moreira (1999, pp. 20-23) estimated that the market share of foreign firms (more than 10% foreign-owned) had risen on average from 41% to 64% between 1980 and 1995, which was greater than the average increase in their share of the manufacturing market as a whole (from 28% to 43% in the period).

[26] The author is extremely grateful for the assistance of Mário Costa Levorato Jr. in carrying out the computer programming required to convert these codes.

1. Industrial structure, productivity and employment

Table 1 shows that the marked adjustment in production and technology that followed trade liberalization did not lead to the demise of the Brazilian capital goods industry. In 2005, the sector accounted for about 12% of all value added in manufacturing industry, which is slightly less than the figure of 14% in 1996.

Nonetheless, in recent years the capital goods industry has undergone substantial changes in its internal structure. The transport machinery and equipment segment was the only one to substantially

TABLE 1

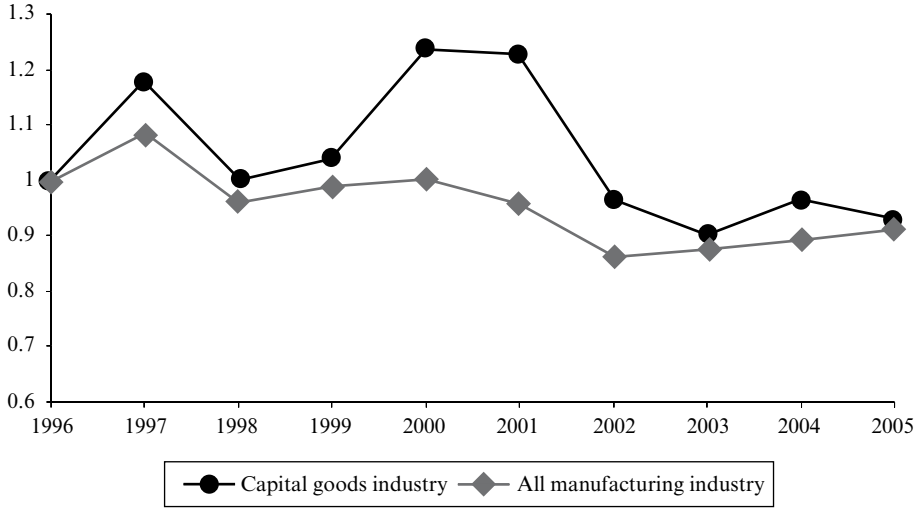
Brazil: composition of value added in the different segments of the capital goods industry
(Percentages)

Segment	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Traditional industrial machinery and equipment	**52.27**	**50.69**	**50.58**	**48.48**	**43.72**	**43.24**	**45.33**	**44.68**	**44.11**	**46.71**
Metal frames and heavy boilers	3.85	3.76	3.99	3.11	2.90	3.29	3.07	2.93	2.93	4.62
Tanks and boilers	1.78	1.39	1.36	1.09	0.88	1.05	1.33	1.34	1.04	0.98
Motors, pumps, compressors and transmission equipment	9.29	8.39	10.12	9.92	8.15	9.33	9.82	10.13	10.16	8.14
General machinery and equipment	10.41	10.48	9.71	10.17	8.71	7.94	8.94	8.28	7.13	8.48
Machine tools	2.52	2.20	1.99	2.11	1.93	1.77	1.96	2.59	2.28	2.27
Mining and construction machinery and equipment	2.63	3.22	3.49	3.11	2.43	3.03	3.17	3.29	3.62	4.23
Other extraction machinery	8.79	8.88	7.47	6.63	6.45	5.57	5.50	5.64	5.55	5.96
Generators, transformers and electric motors	3.55	3.83	4.50	4.25	4.05	4.48	4.40	4.16	4.28	4.49
Other electrical equipment	1.41	1.35	1.21	1.13	1.52	1.07	1.08	1.05	1.12	2.21
Basic electronics	4.95	4.27	3.57	3.63	3.33	2.74	3.04	2.38	3.01	2.22
Measuring, testing and control devices	1.86	1.68	1.81	1.85	2.00	1.74	1.75	1.53	1.77	1.84
Industrial automation equipment	0.55	0.52	0.60	0.60	0.54	0.44	0.55	0.50	0.49	0.60
Optical and photographic equipment and supplies	0.67	0.72	0.76	0.89	0.82	0.80	0.72	0.86	0.74	0.69
Electricity generating equipment	**3.60**	**4.29**	**5.96**	**3.05**	**2.74**	**2.73**	**2.48**	**4.40**	**3.16**	**4.39**
Telecommunications machinery and equipment	**20.38**	**18.79**	**16.04**	**17.96**	**20.37**	**18.30**	**16.19**	**11.74**	**13.38**	**13.74**
Telephony and radio-telephony equipment and television and radio transmitters	9.73	12.48	11.49	14.24	15.49	14.96	11.04	7.64	8.75	8.57
Receiving, playback, recording and amplification devices	10.65	6.30	4.55	3.72	4.87	3.34	5.15	4.11	4.63	5.17
Electronic and non-electronic office machinery and equipment	**3.52**	**3.70**	**3.92**	**5.71**	**7.81**	**8.63**	**5.07**	**5.09**	**3.75**	**4.40**
Office machinery	1.12	1.46	0.34	0.63	3.86	0.15	0.21	0.25	0.13	0.07
Equipment for electronic data processing systems	2.39	2.25	3.58	5.08	3.95	8.48	4.87	4.83	3.63	4.33
Medical and hospital equipment	**2.10**	**1.94**	**2.16**	**2.23**	**2.12**	**1.60**	**2.05**	**2.11**	**2.15**	**2.55**
Agricultural machinery and equipment	**3.42**	**4.23**	**4.69**	**3.61**	**3.53**	**4.39**	**5.52**	**7.79**	**8.84**	**5.12**
Transport machinery and equipment	**14.72**	**16.36**	**16.66**	**18.97**	**19.71**	**21.11**	**23.35**	**24.19**	**24.81**	**23.09**
Trucks and buses	5.64	6.16	5.31	5.16	5.89	5.23	5.92	6.62	5.75	6.68
Truck cabs, bodywork and trailers	3.10	3.07	3.18	2.77	3.02	2.83	2.97	3.31	3.33	3.32
Railway rolling stock construction, assembly and repair	0.42	0.46	1.03	1.10	0.44	0.35	0.41	0.76	0.90	1.49
Boat construction and repair	1.28	1.32	0.73	0.73	0.57	0.67	1.22	2.02	2.05	1.69
Aircraft construction, assembly and repair	1.41	2.28	3.15	6.58	7.08	9.14	9.74	8.08	8.53	5.67
Manufacture of other transport equipment	2.87	3.07	3.26	2.62	2.72	2.90	3.07	3.41	4.26	4.24
Capital goods industry total/manufacturing industry total	**14.01**	**14.72**	**14.19**	**13.32**	**14.20**	**15.58**	**14.19**	**12.03**	**12.55**	**12.12**
Capital goods industry total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: prepared by the author using data from the Annual Industrial Survey (PIA) of the Brazilian Geographical and Statistical Institute (IBGE).

FIGURE 1

Brazil: productivity of the capital goods industry and all manufacturing, 1996-2005
(Index 1996 = 1)



Source: Annual Industrial Survey (PIA) of the Brazilian Geographical and Statistical Institute (IBGE).

increase (from 14.7% to 23.1% between 1996 and 2005) its share of the industry's value added. Although there was a small increase in the share of the electricity generating machinery and equipment, electronic and non-electronic office machinery and equipment and agricultural machinery and equipment sectors in the total value added of the capital goods industry over the same period, the percentage for medical and hospital equipment remained virtually unchanged from the mid-1990s.

Among the groups most affected in recent years are the telecommunications machinery and equipment and the traditional industrial machinery and equipment sectors, whose relative shares in value added fell off greatly between 1996 and 2005. In the telecommunications machinery and equipment sector, it is possible that this contraction may have reflected not just the drying up of investment opportunities after the initial post-privatization surge (after 1998), but also the low average growth rate of the Brazilian economy in the period.

Again, while the production structure of the Brazilian capital goods sector is reasonably diversified, production is heavily concentrated in the traditional industrial machinery and equipment and transport machinery and equipment sectors, which jointly generated almost 70% of capital goods industry value added in 2005. This concentration is not altogether a bad thing, however, since it has increased the opportunities for static or dynamic specialization in the segments where Brazil has a comparative advantage.[27]

The indicator used to measure the domestic performance of the capital goods industry was labour productivity. This indicator is very well-established in economic theory and is defined as the ratio between value added and the number of workers.[28] Figure 1 initially compares cumulative productivity index values in the capital goods industry and manufacturing industry as a whole from 1996. The trend (observed from the start of the period analysed) of higher cumulative average

[27] The international specialization indicators will be analysed in detail further on.

[28] The methodologies most commonly used to calculate labour productivity take the ratio between gross production value and personnel employed and the ratio between physical production and hours worked. Nonetheless, as Bruno (1978) argued in his classic paper, the best measure is the ratio between value added and personnel employed. The fact is, as Bonelli and Fonseca (1998) acknowledge, that if technical coefficients change over time, the measure of production (usually indices of real "physical production") as a proxy for output (i.e., value added) will give very distorted results.

productivity growth in the Brazilian capital goods industry than in manufacturing generally reversed from 2001 onward. In any event, in 1996-2005 both the capital goods industry and manufacturing generally displayed negative average annual growth rates of -0.8% and -1%, respectively (table 2).

Table 2 details average annual rates of growth in value added, employment and labour productivity between 1996 and 2005. This period fell into two parts: the subperiod during which the Brazilian currency was generally overvalued against the dollar in real terms (1996-1998) and the subperiod characterized by substantial undervaluation of the Brazilian real (1999-2005). The use of annual averages allows a clearer picture to be formed of which sectors were able to sustain average real efficiency gains over the whole period.

In Brazil, average changes in labour productivity in the capital goods industry were insignificant both when the real was overvalued (1996-1998) and when it was undervalued (1999-2005).[29] Average annual productivity growth rates in manufacturing industry as a whole were negative in both periods.[30] Between 1996 and 2005, the segments that avoided this adverse trend were electricity generating machinery and equipment, agricultural machinery and equipment and transport machinery and equipment, particularly truck and bus production, railway rolling stock construction and assembly and aeronautical machinery and equipment. In the industrial machinery and equipment group, whose performance in efficiency terms was disappointing, only the other electrical equipment segment showed somewhat higher average annual growth in the period under consideration.

Table 2 also used a measure of relative average productivity calculated as the ratio between productivity in each segment and productivity in the capital goods industry as a whole (both at current prices). Because it does not use price deflators, this indicator serves only to test the consistency of the results obtained for the real-term behaviour of productivity. Thus, if the rate of productivity growth in a given segment is higher than productivity growth in the capital goods industry as a whole, its relative average productivity will be positive, and vice versa. As can be seen, in almost all segments productivity growth and relative average productivity growth had the same sign and in most cases very similar values, which confirms the validity of the deflators used.

We shall now analyse how the behaviour of productivity affected employment in the different segments of the capital goods industry from the second half of the 1990s. The empirical studies available reveal that the productivity of Brazilian manufacturing industry improved in the first half of the 1990s thanks to the acquisition of new equipment (locally made and imported) and the embodiment of technological innovations and organizational change, but that industrial employment fell sharply.[31] However, as the last column of table 2 shows, this trend clearly changed in the second half of the 1990s. In the 1996-2005 period, the labour absorption rate exceeded the rate of real-term growth in value added (annual averages), so that average annual productivity growth was negative in the capital goods industry as in manufacturing generally. In the same period, the behaviour of employment differed appreciably in the various segments of the capital goods industry (see table 2 again).

In summary, it can be concluded:

(i) that only in the other electrical equipment, agricultural machinery and equipment, railway and aeronautical machinery and equipment and other transport equipment segments were productivity improvements accompanied by substantial (average) increases in employment from 1996, and

(ii) that employment was far more volatile in the other sectors over the period analysed, tending sometimes to increase and sometimes to diminish. In any event, whereas between 1996 and 1998 the level of employment in the capital goods industry tended to diminish, average annual employment growth was positive in the period following the deep real-term devaluation of the Brazilian currency against the dollar (1999-2005).

[29] Taking 2000 as the base year, some empirical studies show that the Brazilian real once again tended towards overvaluation from 2003 onward. See, for example, Nassif (2008).

[30] Nassif (2008) showed that the average annual growth of labour productivity in Brazilian manufacturing industry had been negative (-2.9%) between 1996 and 2004, thus reversing the trend towards strong growth (of some 5%) seen in 1990-1996. See also Carvalho (2000).

[31] See, for example, Carvalho (2000) and Nassif (2003a).

TABLE 2

Brazil: value added, employment and productivity in the capital goods industry, 1996-2005[a] [b]

(Average annual growth rates)

Capital goods industry segment	1996-1998				1999-2005				1996-2005			
	Value added	Employment	Productivity	Relative average productivity	Value added	Employment	Productivity	Relative average productivity	Value added	Employment	Productivity	Relative average productivity
Traditional industrial machinery and equipment	**-4.85**	**-2.28**	**-2.63**	**-2.66**	**1.10**	**3.42**	**-2.24**	**-0.36**	**-1.16**	**1.87**	**-2.97**	**-2.21**
Metal frames and heavy boilers	-1.55	3.27	-4.67	-4.70	8.65	4.68	3.79	3.71	2.14	3.59	-1.41	-0.63
Tanks and boilers	-15.63	-9.28	-7.00	-7.03	-0.17	1.87	-2.00	-0.19	-6.40	-0.38	-6.05	-5.30
Motors, pumps, compressors and transmission equipment	0.98	0.84	0.14	0.11	-1.57	1.89	-3.39	-1.13	-1.37	1.82	-3.13	-2.36
General machinery and equipment	-6.61	-4.51	-2.20	-2.24	-1.31	0.71	-2.01	-0.19	-2.18	0.52	-2.68	-1.91
Machine tools	-14.06	-11.76	-2.61	-2.65	2.96	5.55	-2.45	-0.50	-1.10	1.43	-2.50	-1.73
Mining and construction machinery and equipment	11.40	6.15	4.94	4.90	7.07	11.78	-4.21	-1.70	5.49	8.53	-2.80	-2.03
Other extraction machinery	-10.79	-3.84	-7.23	-7.27	-0.07	1.98	-2.01	-0.19	-4.14	-0.29	-3.86	-3.10
Generators, transformers and electric motors	8.92	2.10	6.68	6.64	2.67	6.31	-3.42	-1.16	2.73	3.98	-1.21	-0.42
Other electrical equipment	-10.59	-15.37	5.64	5.61	13.75	12.46	1.15	1.94	5.18	3.32	1.80	2.61
Basic electronics	-17.84	-10.21	-8.50	-8.54	-6.27	3.65	-9.57	-5.40	-8.44	0.87	-9.23	-8.51
Measuring, testing and control devices	-4.60	6.90	-10.75	-10.79	1.63	-2.45	4.18	3.96	-0.06	-0.20	0.14	0.93
Industrial automation equipment	1.48	1.50	-0.01	-0.05	1.88	10.98	-8.20	-4.44	1.20	7.71	-6.05	-5.30
Optical and photographic equipment and supplies	2.70	-5.37	8.52	8.48	-2.44	0.38	-2.80	-0.73	0.45	0.46	-0.01	0.78
Electricity generating equipment	**24.39**	**8.32**	**14.84**	**14.80**	**8.10**	**-2.37**	**10.72**	**8.27**	**2.30**	**-2.30**	**4.70**	**5.53**
Telecommunications machinery and equipment	**-14.19**	**-10.54**	**-4.08**	**-4.12**	**-2.71**	**4.51**	**-6.91**	**-3.55**	**-4.20**	**-0.03**	**-4.17**	**-3.41**
Telephony and radio-telephony equipment and television and radio transmitters	5.12	5.49	-0.35	-0.38	-6.53	2.39	-8.71	-4.80	-1.32	4.59	-5.65	-4.90
Receiving, playback, recording and amplification devices	-36.79	-19.23	-21.74	-21.77	7.46	6.81	0.61	1.57	-7.63	-3.01	-4.77	-4.02
Electronic and non-electronic office machinery and equipment	**2.09**	**2.60**	**-0.50**	**-0.53**	**-2.59**	**7.97**	**-9.78**	**-5.54**	**2.61**	**5.89**	**-3.09**	**-2.33**
Office machinery	-46.80	-47.38	1.11	1.07	-29.08	-9.73	-21.44	-13.86	-26.16	-18.77	-9.10	-8.38
Equipment for electronic data processing systems	18.24	20.60	-1.96	-2.00	-0.94	9.14	-9.23	-5.16	6.89	10.52	-3.28	-2.52
Medical and hospital equipment	**-2.06**	**3.50**	**-5.37**	**-5.41**	**4.00**	**3.03**	**0.94**	**1.80**	**2.25**	**3.13**	**-0.86**	**-0.07**
Agricultural machinery and equipment	**13.34**	**8.31**	**4.64**	**4.61**	**7.84**	**6.14**	**1.60**	**2.24**	**4.70**	**4.05**	**0.63**	**1.42**
Transport machinery and equipment	**2.91**	**-3.00**	**6.09**	**6.06**	**5.12**	**9.70**	**-4.18**	**-1.67**	**5.22**	**4.96**	**0.25**	**1.04**
Trucks and buses	-6.16	-10.17	4.47	4.43	6.19	1.61	4.51	4.19	1.98	-1.44	3.47	4.29
Truck cabs, bodywork and trailers	-2.00	1.09	-3.05	-3.08	4.85	5.41	-0.53	0.81	0.86	2.59	-1.68	-0.90
Railway rolling stock construction, assembly and repair	51.99	1.27	50.08	50.02	6.94	15.17	-7.15	-3.72	15.30	11.25	3.64	4.46
Boat construction and repair	-27.01	-24.93	-2.77	-2.81	17.07	26.18	-7.22	-3.77	3.24	8.97	-5.25	-4.50
Aircraft construction, assembly and repair	44.57	15.06	25.65	25.60	-0.76	14.50	-13.33	-8.04	16.83	15.59	1.07	1.87
Manufacture of other transport equipment	3.09	1.93	1.13	1.09	10.19	9.91	0.26	1.34	4.50	4.44	0.06	0.85
Capital goods industry total	**-1.58**	**-1.62**	**0.04**	**0.00**	**2.30**	**4.09**	**-1.72**	**0.00**	**1.32**	**2.12**	**-0.78**	**0.00**
Manufacturing industry total	**-3.88**	**-2.00**	**-1.92**	–	**3.35**	**4.73**	**-1.32**	–	**1.72**	**2.78**	**-1.03**	–

Source: prepared by the author using data from the Annual Industrial Survey (PIA).

[a] The industrial value added figures were calculated at constant 1996 prices on the basis of the sectoral wholesale price indices calculated by the Getulio Vargas Foundation.

[b] Relative average productivity is expressed as the ratio between the productivity of each segment at current prices and the productivity of the capital goods industry, also at current prices.

2. Sectoral value added and vertical integration

In some studies, it is common to measure the degree to which value is added to the goods produced by the ratio between value added (VA) and gross output value (GOV). For example, when a paper by the Industrial Development Research Institute (IEDI, 2007) found a marked reduction in the VA/GOV ratio in various (three-digit) segments of Brazilian manufacturing industry between 1996 and 2004, it concluded that this result indicated a diminution of value added per item produced and thus of national content in Brazilian industrial output, and consequently that the deindustrialization of the Brazilian economy had intensified over the period.[32] Going by this methodology, the data in table 3 could

[32] However, the study uses other indicators to evaluate the supposed deindustrialization of the Brazilian economy in the period analysed. See IEDI (2007) for further details.

TABLE 3

Brazil: ratio between value added and gross output value in the capital goods industry, 1996-2005

Capital goods industry segment	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Traditional industrial machinery and equipment	**0.53**	**0.52**	**0.50**	**0.50**	**0.49**	**0.47**	**0.47**	**0.45**	**0.44**	**0.42**
Metal frames and heavy boilers	0.51	0.51	0.46	0.43	0.48	0.50	0.45	0.46	0.42	0.46
Tanks and boilers	0.54	0.44	0.40	0.42	0.40	0.46	0.45	0.44	0.43	0.41
Motors, pumps, compressors and transmission equipment	0.56	0.56	0.55	0.55	0.52	0.49	0.47	0.45	0.44	0.41
General machinery and equipment	0.53	0.53	0.49	0.49	0.47	0.46	0.48	0.45	0.41	0.41
Machine tools	0.58	0.57	0.53	0.55	0.53	0.51	0.52	0.50	0.52	0.48
Mining and construction machinery and equipment	0.47	0.42	0.40	0.48	0.44	0.46	0.49	0.43	0.38	0.36
Other extraction machinery	0.56	0.57	0.52	0.51	0.51	0.46	0.49	0.45	0.46	0.42
Generators, transformers and electric motors	0.48	0.46	0.47	0.48	0.48	0.45	0.45	0.46	0.46	0.40
Other electrical equipment	0.53	0.53	0.56	0.53	0.54	0.47	0.54	0.51	0.56	0.47
Basic electronics	0.51	0.49	0.43	0.43	0.40	0.39	0.39	0.35	0.51	0.34
Measuring, testing and control devices	0.59	0.54	0.55	0.53	0.57	0.52	0.47	0.45	0.46	0.49
Industrial automation equipment	0.63	0.63	0.68	0.58	0.55	0.55	0.57	0.57	0.61	0.54
Optical and photographic equipment and supplies	0.56	0.58	0.60	0.55	0.55	0.54	0.54	0.62	0.60	0.59
Electricity generating equipment	**0.55**	**0.55**	**0.60**	**0.54**	**0.52**	**0.52**	**0.41**	**0.47**	**0.48**	**0.52**
Telecommunications machinery and equipment	**0.45**	**0.44**	**0.40**	**0.36**	**0.38**	**0.37**	**0.36**	**0.29**	**0.25**	**0.29**
Telephony and radio-telephony equipment and television and radio transmitters	0.57	0.54	0.43	0.38	0.40	0.40	0.38	0.30	0.24	0.27
Receiving, playback, recording and amplification devices	0.37	0.33	0.33	0.32	0.33	0.27	0.33	0.27	0.29	0.32
Electronic and non-electronic office machinery and equipment	**0.44**	**0.38**	**0.37**	**0.41**	**0.35**	**0.45**	**0.37**	**0.35**	**0.31**	**0.31**
Office machinery	0.50	0.75	0.34	0.59	0.52	0.54	0.33	0.42	0.80	0.33
Equipment for electronic data processing systems	0.42	0.29	0.37	0.40	0.26	0.45	0.37	0.35	0.31	0.31
Medical and hospital equipment	**0.67**	**0.65**	**0.61**	**0.61**	**0.62**	**0.57**	**0.59**	**0.55**	**0.58**	**0.61**
Agricultural machinery and equipment	**0.49**	**0.45**	**0.39**	**0.41**	**0.40**	**0.41**	**0.40**	**0.39**	**0.39**	**0.37**
Transport machinery and equipment	**0.42**	**0.40**	**0.37**	**0.39**	**0.40**	**0.40**	**0.43**	**0.37**	**0.34**	**0.32**
Trucks and buses	0.38	0.79	0.31	0.32	0.36	0.34	0.37	0.31	0.27	0.27
Truck cabs, bodywork and trailers	0.44	0.42	0.39	0.44	0.41	0.39	0.40	0.37	0.35	0.34
Railway rolling stock construction, assembly and repair	0.62	0.55	0.52	0.58	0.48	0.46	0.47	0.55	0.50	0.45
Boat construction and repair	0.55	0.50	0.50	0.48	0.46	0.52	0.46	0.48	0.28	0.39
Aircraft construction, assembly and repair	0.53	0.51	0.39	0.42	0.47	0.47	0.55	0.47	0.44	0.34
Manufacture of other transport equipment	0.38	0.36	0.37	0.34	0.32	0.33	0.32	0.29	0.34	0.31
Capital goods industry total	**0.49**	**0.48**	**0.45**	**0.44**	**0.43**	**0.43**	**0.43**	**0.40**	**0.37**	**0.36**

Source: Annual Industrial Survey (PIA).

lead to the false conclusion that the capacity to add value to the goods produced had diminished in almost all segments of the capital goods industry, this finding being one of the symptoms of the supposed "deindustrialization" of Brazil. Following this reasoning, furthermore, the results would indicate that the medical and hospital equipment, electricity generating machinery and equipment and traditional industrial machinery and equipment segments were the ones with the greatest capacity to add value in the Brazilian capital goods industry in 2005.

However, this kind of interpretation is not supported by theoretical and empirical studies of industrial organization, where the VA/GOV ratio is firmly established as one of the most appropriate measures for determining the degree of vertical integration at the firm level (Scherer and Ross, 1990, chapter 3). Accordingly, a firm's VA/GOV index can range from 0 (total absence of vertical integration) to 1 (full vertical integration, i.e., the firm manufactures not only the product but all the inputs used in the production process). It is obvious that the index can fall even in cases that do not constitute a traditional horizontal integration strategy, such as the subcontracting of cleaning and repair services or the outsourcing of functions and tasks, trends that have become common with the fragmentation of production activities in Brazil and around the world since the 1990s. However, when this happens the firm will seek to hold costs down by cutting back on production activities or transferring some production to other companies.

The indicator proposed by Scherer and Ross (1990) is appropriate for evaluating vertical integration trends not only within a firm but throughout the industry, provided the classification is at an intermediate level (up to three digits, as in the present study). In the case of the Brazilian capital goods industry, all segments, with the exception of the optical and photographic equipment and machinery segment, saw a decline in the VA/GOV indicator between 1996 and 2005, something indicative not so much of deindustrialization and a contracting industry[33] as of greater "vertical division of labour"[34] (see table 3 again). This greater specialization, which may also include a rise in imports, does not necessarily entail an increase in labour productivity.[35] Indeed, recent Brazilian experience shows that attempting to lower costs by reducing the degree of vertical integration in firms operating in the capital goods sector (table 3) has not resulted in greater labour efficiency in most segments of that industry (table 2). In any event, the data in table 3 confirm that the capital goods industry has carried on trying to cut production costs by a continuing retreat from vertical integration, a trend observable from the very onset of trade liberalization in the early 1990s.[36]

3. The technology gap between the Brazilian capital goods industry and the international technology frontier

Although it is difficult to estimate how far the technologies adopted by a particular firm, segment or industrial sector lag behind the latest advances in the world economy, economists generally attempt to do so by using a proxy variable, labour productivity in the industry of the country concerned compared with that in the industry of the country acknowledged to be at the forefront of world technological development. Since no one country is likely to be in the technological vanguard in all segments of a particular industrial sector, the most advanced

[33] Note that, according to the table 1 data, the decline in the total manufacturing share of the capital goods industry (measured by value added) was less than two percentage points between 1996 and 2005.

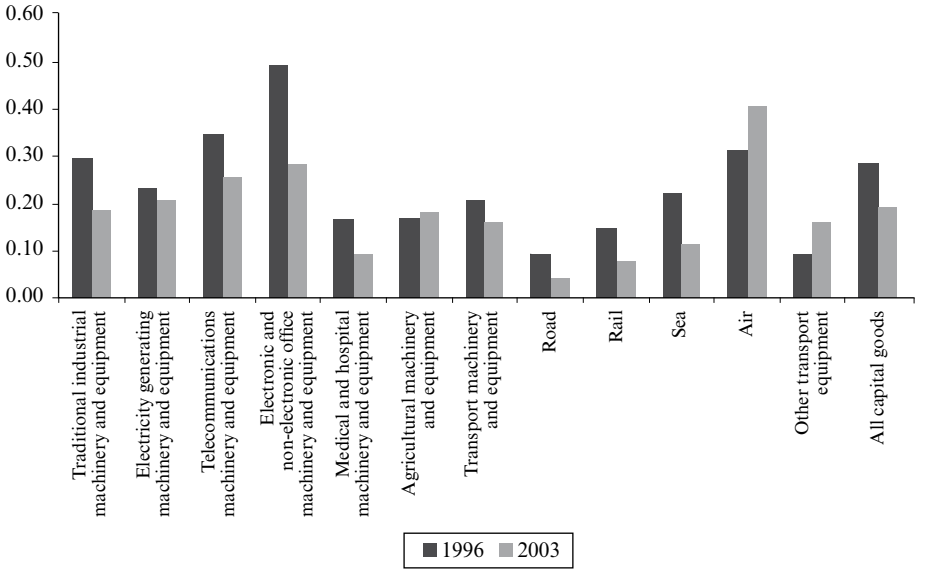
[34] This expression was suggested by Mário Luiz Possas of the Economics Institute of the Federal University of Rio de Janeiro.

[35] In the study by the Industrial Development Research Institute (IEDI, 2007), the author seems to be surprised that the VA/GOV ratio of the oil refining segment should have risen from 54.1% to 68.5% between 1994 and 2004. However, this degree of vertical integration is exactly equal to that seen in the mid-1950s in the United States oil industry (the most vertically integrated of any industry in the United States industrial sector), a situation that did not change greatly in the following period (Scherer and Ross, 1990, pp. 95-96). Furthermore, the oil refining segment was the one that advanced most in terms of its share in the value added and total investment of Brazilian industry in the second half of the 1990s (Nassif and Puga, 2004).

[36] Because values are given in current prices, shifts in the VA/GOV ratio may be distorted by relative price changes. If there has been a large increase in input prices over the period analysed, the VA/GOV indicator could fall (because of the increase in the denominator) without thereby denoting a reversal in vertical integration. Nonetheless, in the case of Brazil particularly, wholesale sectoral price indices in the 1996-2005 period show industrial raw material prices rising by hardly more than those for machinery, vehicles and equipment. This indicates that relative price changes were not so great as to distort the economic significance of this indicator (see Ipeadata for tables and charts dealing with wholesale price indices for machinery, vehicles and equipment and industrial raw materials; available at http://www.ipea.gov.br).

FIGURE 2

Brazil: technology gap between the country's capital goods industry and the same industry in the United States, 1996 and 2003[a]



Source: prepared by the author using data from the Annual Industrial Survey (PIA), the Census Bureau of the United States Department of Commerce and the Bureau of Labor Statistics of the United States Department of Labor.

[a] Productivity gaps were calculated from the ratio between the labour productivity of Brazilian industry and the labour productivity of United States industry. The two values were first converted into constant values at 1996 prices (current prices deflated by, respectively, the sectoral wholesale price indices of the Getulio Vargas Foundation and the sectoral wholesale price indices of the United States). The productivity of Brazilian industry was then converted into 2000 dollars at real purchasing power parity.

country is generally deemed to be the one which occupies the leading position in the sectors that are most important in terms of technology content.

In the case of the capital goods industry, for example, the United States may be considered, on average, to be the most technologically advanced country. It also seems to have managed a sustained increase in productivity in that industry. All segments of the United States capital goods industry other than telecommunications machinery and equipment displayed positive index values for cumulative labour productivity growth between 1996 and 2003. In that period, the labour efficiency of the United States capital goods industry grew at an average annual rate of 2.3% in real terms. The greatest increase in cumulative labour productivity index values was observed in the medical and hospital machinery and equipment, transport machinery and equipment and agricultural machinery and equipment sectors.[37]

This subsection estimates the recent evolution and current situation of the technology gap between the Brazilian capital goods industry and the same industry in the United States.[38] The estimate is based on the ratio between the labour productivity indices of the two countries, at 1996 prices; those of Brazil were converted into dollars at purchasing power parity (figure 2).

[37] See Nassif (2007).

[38] The classification used for the capital goods industry is the same as in the previous sections. Reconciliation was carried out between the nomenclature of the CNAE, on the one hand, and the Census Bureau of the United States Department of Commerce and the Bureau of Labor Statistics of the United States Department of Labor, on the other. The results for certain sectors might present greater distortions owing to the large disparity between the number of segments with production capacity in the two countries. In the aeronautical machinery and equipment sector, for example, the United States industry has segments producing items such as missiles, rockets and high-technology aeronautical equipment that are scarcely produced in Brazil. The estimates only run up to 2003 because data on the United States industry are not available for subsequent years.

Between 1996 and 2003, the Brazilian capital goods industry fell much further behind the international technology frontier, with the technology gap ratio rising from 70% to 81%. The picture was broadly the same across all segments of the industry other than agricultural machinery and equipment, aeronautical machinery and equipment and other transport equipment.

In the Brazilian capital goods industry, the aeronautical segment was the one that came closest to the international technology frontier.[39] Although this industry fell further behind between 1996 and 2003, towards the end of the period the electronic and non-electronic office machinery and equipment, telecommunications machinery and equipment and electricity generating machinery and equipment segments displayed levels of relative technological progress higher than the average for the capital goods industry.

It is evident that this type of methodology cannot really capture how much ground a country's industry needs to make up in terms of technology, since a great deal of material progress is due to the evolution of "disembodied" technology, i.e., that resulting from the search for new production processes or new products in public or private R&D laboratories. However, precisely because this methodology does not capture the qualitative aspects of the technology divide,[40] the results shown in figure 2 indicate that it will not be easy to make up the ground lost by the Brazilian capital goods industry. As well as catching up and sustaining productivity increases higher than the average for the most technologically advanced countries, the industry will have to pursue greater private R&D spending and technology absorption, launch more new products and attain minimum efficient scales in segments subject to economies of scale.

4. The structure and dynamic of external trade

As theoretical studies have long been showing, external trade flows are a reflection in static terms of comparative advantage (or disadvantage) levels and in dynamic terms of intersectoral changes in competitiveness (dynamic comparative advantage).[41] At a higher level of aggregation, they are also influenced by macroeconomic variables such as real GDP growth rates and, above all, the real exchange rate. Although this subsection will concentrate primarily on the external trade behaviour of the Brazilian capital goods industry from the microeconomic point of view, it will begin by setting forth some considerations relating to the behaviour of the industry's trade flows at the aggregate level.

As figure 3 shows, since the early 1990s Brazilian capital goods imports have invariably grown faster than exports. In the first half of the decade this behaviour was due to the immediate effects of trade liberalization, but the considerable strengthening of the real exchange rate (leading to an overvalued Brazilian real) between 1994 and 1998 accounts for the huge difference between the high growth rates of imports and the low growth rates of exports during that time. With the devaluation of the Brazilian real in 1999, capital goods imports fell considerably. With the renewed trend towards overvaluation of the Brazilian currency in real terms from 2003 onward, however, they began to grow much faster than exports again. There now follows an analysis of the data available on the international trade behaviour of the Brazilian capital goods industry at a more disaggregated level.

The revealed comparative advantage indicators (a measure traditionally used to identify the sectors with the greatest net exporting potential) confirm the enormous relative competitive disadvantage under which the Brazilian capital goods industry works (table 4). Comparative disadvantage is found in all segments except agricultural machinery and equipment, road transport and aeronautical machinery and equipment, mining and construction machinery and equipment, and telephony and radio-telephony machinery and equipment and television and radio transmitters.[42] Since the indicators referred to are static indicators of international competitiveness, it cannot be stated categorically that certain segments with a comparative disadvantage in 2006 will be unable to alter this situation in the

[39] The state of relative technological advance of the Brazilian aeronautical industry may have been underestimated for the reasons given in the previous footnote.

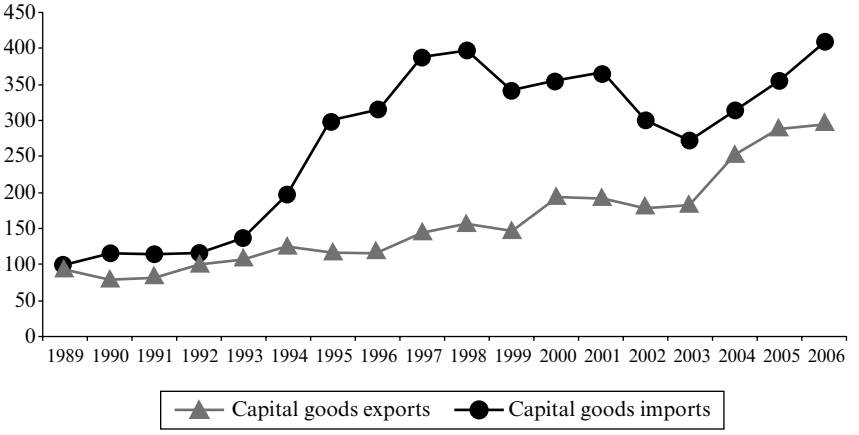
[40] It should be noted here that the electronic and non-electronic office machinery and equipment segment in Brazil is not only highly internationalized, but is basically an assembly industry.

[41] To cite two indispensable works, see Helpman and Krugman (1985) for a more orthodox view and Dosi, Pavitt and Soete (1990) for a neo-Schumpeterian approach.

[42] The RCA index values for the metal frames and heavy boilers segment and the tanks and boilers segment are close to zero.

FIGURE 3

Brazil: capital goods exports and imports,[a] 1989-2006
(1989 = 100)



Source: Foreign Trade Department (SECEX) of the Ministry of Development, Industry and Commerce (MDIC).

[a] Export and import values were originally converted into constant 1989 dollars, using the United States producer price index (PPI) as the deflator.

medium or long term. To succeed in doing so, however, they will have to adopt various strategies with a view to raising their productivity considerably, including higher R&D spending, larger production scales and a greater export effort.[43]

The following two tables present the composition and dynamic of Brazilian capital goods exports and imports, respectively. Table 5 shows that, thanks to higher average annual growth rates in certain segments, external sales of capital goods rose from 26.9% of manufacturing exports in 1989 to 29.2% in 2006. This indicates that, while fairly concentrated in a few segments, the export base of Brazilian machinery and equipment is fairly substantial. The data in the table reveal that capital goods export growth rates were much lower between 1989 and 1998 than in the period after 1999, which suggests that external sales of machinery and equipment may have been affected both by the immediate aftermath of trade liberalization (1989-1994 period) and by the overvaluation of the Brazilian currency against the dollar (1995-1998). Following the rapid weakening of the real exchange rate in 1999, when the initial cycle of industrial and technological restructuring that ensued upon trade liberalization may be considered to have ended, Brazilian capital goods exports saw much higher average annual growth rates.

There were major changes in the composition of capital goods exports over the period analysed. Between 1989 and 2006, the segments whose shares fell most were traditional industrial machinery and equipment (especially mining and construction machinery and equipment and other extraction equipment) and electronic and non-electronic office machinery and equipment. Conversely, while the telecommunications machinery and equipment sector substantially increased its share of external sales of capital goods between 1989 and 2006 (owing exclusively to larger exports of telephony and radio-telephony equipment and radio and television transmitters), the other groups maintained their original relative positions.

[43] It may seem contradictory to recommend an increased export effort by certain segments operating at a comparative disadvantage. However, bilateral trade with countries of a similar technology and per capita income level (e.g., with MERCOSUR partners and other countries in Latin America, or under free trade agreements with countries whose development models are similar) can be a means of increasing the net exports of the more traditional segments of the capital goods industry, such as metal frames and heavy boilers, tanks and boilers, motors, pumps and transmission equipment and machine tools. According to the so-called "new trade theories", the main strategy for raising international competitiveness in sectors subject to economies of scale is to strengthen trading relationships with partners that have fairly similar technology and demand patterns. See Helpman and Krugman (1985) and Krugman (1987).

TABLE 4

Brazil: indices of revealed comparative advantage[a] in the capital goods industry

Capital goods industry segment	1989	1994	1998	2006
Traditional industrial machinery and equipment	**-6.36**	**-8.07**	**-8.96**	**-12.08**
Metal frames and heavy boilers	0.03	0.08	-0.01	0.02
Tanks and boilers	-0.02	0.06	-0.04	0.03
Motors, pumps, compressors and transmission equipment	-0.98	-1.35	-0.88	-1.53
General machinery and equipment	-0.32	-0.53	-1.35	-1.09
Machine tools	-0.68	-0.72	-0.77	-0.63
Mining and construction machinery and equipment	0.59	0.62	0.34	0.47
Other extraction machinery	-1.53	-2.77	-2.48	-1.69
Generators, transformers and electric motors	-0.38	-0.06	-0.47	-0.16
Other electrical equipment	-0.23	-0.23	-0.24	-0.16
Basic electronics	-1.78	-2.08	-1.83	-4.99
Measuring, testing and control devices	-1.00	-0.95	-1.01	-1.31
Optical and photographic equipment and supplies	-0.07	-0.15	-0.23	-1.04
Electricity generating equipment	**-0.55**	**-0.79**	**-0.60**	**-0.70**
Telecommunications machinery and equipment	**-0.49**	**-1.49**	**-2.39**	**-2.62**
Telephony and radio-telephony equipment and television and radio transmitters	-0.26	-0.66	-1.60	0.82
Receiving, playback, recording and amplification devices	-0.23	-0.83	-0.79	-3.45
Electronic and non-electronic office machinery and equipment	**-0.77**	**-1.93**	**-1.48**	**-2.68**
Office machinery	-0.11	-0.28	-0.15	-0.08
Equipment for electronic data processing systems	-0.66	-1.64	-1.33	-2.60
Medical and hospital equipment	**-0.62**	**-0.57**	**-0.67**	**-0.89**
Agricultural machinery and equipment	**0.16**	**0.12**	**0.08**	**0.19**
Transport machinery and equipment	**1.57**	**1.82**	**0.92**	**2.04**
Trucks and buses	1.89	0.93	0.59	1.88
Truck cabs, bodywork and trailers	0.09	0.35	0.24	0.36
Railway rolling stock construction, assembly and repair	-0.01	0.01	-0.10	-0.16
Boat construction and repair	0.01	0.62	0.14	-0.01
Aircraft construction, assembly and repair	-0.39	0.22	0.17	0.08
Manufacture of other transport equipment	-0.01	-0.31	-0.12	-0.11
Capital goods industry total	**-7.06**	**-10.91**	**-13.11**	**-16.74**

Source: prepared by the author using data from the Foreign Trade Department (SECEX) of the Ministry of Development, Industry and Commerce (MDIC) and Ipeadata.

a The revealed comparative advantage (RCA) index values were calculated on the basis of the methodology proposed by Lafay (1979 and 1990). In the table, positive RCA figures indicate that the segment has a comparative advantage and negative figures that is has a comparative disadvantage. The methodology is as follows:
Revealed comparative advantage index: RCA = (1,000/GDP) x {(EXPi - IMPi) - (EXPi + IMPi)[(EXP - IMP) / (EXP + IMP)]}, where
EXPi = exports in segment i
IMPi = imports in segment i
EXP = total country exports
IMP = total country imports
GDP = gross domestic product of Brazil; all values expressed in dollars.

It should be noted that the composition of exports in the transport machinery and equipment segment changed, with a considerable decline in the external sales share of trucks and buses and a substantial increase in that of aeronautical equipment. In any event, the segments with the greatest weight in Brazilian capital goods exports in 2006 were those producing aeronautical equipment (17.1%), trucks and buses (16.9%), telephony and radio-telephony equipment and television and radio transmitting equipment (13.7%) and motors, pumps, transmitters and transmission equipment (10.2%).

Table 6 suggests that the behaviour of capital goods imports has been adversely affected by changes in the macroeconomic environment. Very high average rates of growth in Brazilian capital goods imports between 1989 and 1998 reflected not just the early effects of liberalization (1990-1994) but

TABLE 5

Brazil: share of capital goods industry segments in capital goods exports, 1989-2006
(Percentages and real average annual growth)

Capital goods industry segment	1989	1994	1998	2006	1989-1994	1995-1998	1999-2006	1989-2006
	Percentages				Real average annual growth			
Traditional industrial machinery and equipment	**42.01**	**47.33**	**41.22**	**37.43**	**9.12**	**2.54**	**8.15**	**6.27**
Metal frames and heavy boilers	0.46	0.94	0.61	0.51	26.38	-7.27	6.95	7.66
Tanks and boilers	0.50	0.77	0.54	0.57	18.25	-4.54	10.61	8.04
Motors, pumps, compressors and transmission equipment	9.97	11.94	11.06	10.20	10.80	4.66	8.39	7.19
General machinery and equipment	5.61	8.08	5.59	4.70	16.01	-5.02	6.96	5.86
Machine tools	1.34	1.94	2.25	1.56	16.33	12.75	4.02	8.07
Mining and construction machinery and equipment	9.51	8.51	7.50	6.55	2.99	2.96	7.56	4.57
Other extraction machinery	6.84	5.15	4.45	3.76	-1.36	2.24	7.05	3.10
Generators, transformers and electric motors	2.30	4.51	3.80	6.09	25.26	1.41	17.32	13.75
Other electrical equipment	0.47	0.61	0.94	0.38	13.07	24.35	-3.60	5.71
Basic electronics	2.20	2.16	2.24	1.25	5.35	8.80	0.85	3.31
Measuring, testing and control devices	1.37	2.33	1.90	1.62	20.96	0.41	7.21	8.20
Optical and photographic equipment and supplies	1.43	0.40	0.34	0.23	-23.00	1.81	3.77	-4.47
Electricity generating equipment	**1.31**	**1.74**	**1.41**	**1.28**	**13.78**	**0.05**	**8.14**	**6.88**
Telecommunications machinery and equipment	**9.55**	**6.13**	**6.90**	**15.22**	**-5.20**	**11.70**	**22.77**	**10.20**
Telephony and radio-telephony equipment and television and radio transmitters	0.94	0.74	2.61	13.74	-0.31	63.68	39.05	26.59
Receiving, playback, recording and amplification devices	8.61	5.39	4.29	1.48	-5.78	-0.48	-5.81	-4.11
Electronic and non-electronic office machinery and equipment	**4.17**	**2.60**	**4.09**	**2.27**	**-5.89**	**24.92**	**0.80**	**3.05**
Office machinery	1.28	1.14	1.30	0.65	3.01	11.96	-0.58	2.64
Equipment for electronic data processing systems	2.89	1.46	2.80	1.62	-10.78	33.49	1.41	3.23
Medical and hospital equipment	**0.45**	**0.74**	**0.87**	**1.01**	**19.73**	**13.30**	**12.12**	**12.58**
Agricultural machinery and equipment	**2.19**	**2.20**	**2.94**	**2.15**	**5.92**	**18.32**	**4.86**	**6.90**
Transport machinery and equipment	**40.33**	**39.27**	**42.58**	**40.64**	**5.21**	**10.31**	**8.92**	**7.09**
Trucks and buses	22.87	19.89	18.92	16.86	2.28	5.59	7.86	5.02
Truck cabs, bodywork and trailers	2.08	4.99	4.96	4.57	31.79	7.14	8.38	12.43
Railway rolling stock construction, assembly and repair	0.34	0.26	0.27	0.65	-1.63	9.16	24.35	11.37
Boat construction and repair	1.14	6.09	1.52	0.14	60.97	-32.44	-22.34	-6.31
Aircraft construction, assembly and repair	13.42	7.51	16.43	17.11	-8.40	39.42	10.29	8.68
Manufacture of other transport equipment	0.47	0.54	0.49	1.32	9.63	3.82	26.39	14.17
Capital goods industry total	**100.00**	**100.00**	**100.00**	**100.00**	**5.91**	**7.38**	**9.65**	**7.04**
Capital goods industry/manufacturing industry	**26.90**	**27.12**	**29.46**	**29.23**	**5.70**	**4.45**	**9.77**	**6.48**

Source: prepared by the author using data from the Secretariat of Foreign Trade (SECEX) of the Ministry of Development, Industry and Commerce (MDIC). Exports were converted into constant 1989 dollars on the basis of the United States producer price index (PPI).

also those deriving from a long period of currency overvaluation (1994-1998). Meanwhile, the very low average annual growth of machinery and equipment imports in 1999-2006 (just 0.4% in real terms) reflected the sharp currency devaluation which occurred between 1999 and 2003, and also the low average growth rates of the Brazilian economy in the same period (some 2.4%). Thus, capital goods imports as a share of all manufacturing imports dropped to 32.2% in 2006 after rising from 26.9% to 37.3% between 1989 and 1998.

Regarding changes in the composition of capital goods imports, the segments whose share declined were traditional industrial machinery and equipment (almost 10 percentage points), medical and hospital equipment and electricity generating

TABLE 6

Brazil: share of capital goods industry segments in capital goods imports, 1989-2006
(Percentages and real average annual growth rates)

Capital goods industry segment	1989	1994	1998	2006	1989-1994	1995-1998	1999-2006	1989-2006
	Percentages				Real average annual growth			
Traditional industrial machinery and equipment	**64.05**	**60.75**	**56.07**	**54.99**	**16.85**	**22.96**	**0.14**	**8.14**
Metal frames and heavy boilers	0.04	0.08	0.30	0.19	39.64	97.05	-5.78	20.27
Tanks and boilers	0.37	0.12	0.42	0.20	-10.95	92.28	-9.59	5.07
Motors, pumps, compressors and transmission equipment	11.77	12.17	8.69	9.66	19.39	12.88	1.94	7.84
General machinery and equipment	5.13	6.48	8.17	5.62	25.51	36.47	-4.82	9.80
Machine tools	5.13	4.28	4.24	2.66	13.21	25.85	-6.05	4.79
Mining and construction machinery and equipment	1.31	1.34	1.99	1.81	19.20	43.93	-0.94	11.41
Other extraction machinery	13.62	15.33	12.36	6.97	21.95	17.55	-7.47	4.71
Generators, transformers and electric motors	3.74	2.49	3.68	3.49	6.94	43.89	-0.36	8.70
Other electrical equipment	1.71	1.36	1.42	0.69	11.78	28.05	-9.49	3.11
Basic electronics	12.74	10.65	8.65	15.68	13.20	17.83	9.33	10.60
Measuring, testing and control devices	7.22	5.56	5.05	4.75	10.88	22.38	-0.47	6.36
Optical and photographic equipment and supplies	1.25	0.90	1.10	3.27	8.94	35.21	17.29	15.92
Electricity generating equipment	**4.29**	**4.51**	**3.15**	**2.75**	**19.89**	**12.12**	**-1.53**	**6.19**
Telecommunications machinery and equipment	**8.33**	**9.91**	**13.10**	**15.45**	**23.65**	**38.60**	**2.81**	**13.48**
Telephony and radio-telephony equipment and television and radio transmitters	2.18	3.42	7.86	4.30	32.46	66.73	-7.87	13.91
Receiving, playback, recording and amplification devices	6.15	6.49	5.23	11.15	20.02	17.55	11.87	13.32
Electronic and non-electronic office machinery and equipment	**7.28**	**10.18**	**8.03**	**9.23**	**28.76**	**16.70**	**2.42**	**10.81**
Office machinery	1.42	1.88	1.22	0.58	27.08	9.19	-9.76	3.20
Equipment for electronic data processing systems	5.86	8.30	6.82	8.65	29.15	18.28	3.89	11.87
Medical and hospital equipment	**4.26**	**3.01**	**3.19**	**3.18**	**8.59**	**28.76**	**0.36**	**7.20**
Agricultural machinery and equipment	**0.13**	**0.53**	**1.00**	**0.48**	**69.53**	**56.16**	**-9.52**	**18.74**
Transport machinery and equipment	**11.67**	**11.12**	**15.46**	**13.92**	**16.97**	**40.98**	**-1.08**	**10.39**
Trucks and buses	0.14	5.60	6.13	2.66	199.08	30.17	-10.89	31.37
Truck cabs, bodywork and trailers	0.57	0.86	1.23	1.17	31.00	42.23	-0.24	14.17
Railway rolling stock construction, assembly and repair	0.23	0.09	0.53	0.81	-6.04	127.45	6.82	18.22
Boat construction and repair	0.56	0.17	0.09	0.08	-11.91	3.04	-1.31	-3.14
Aircraft construction, assembly and repair	9.83	2.69	6.76	8.22	-14.33	71.60	3.25	7.96
Manufacture of other transport equipment	0.34	1.70	0.73	0.98	77.52	-4.84	4.75	16.70
Capital goods industry total	**100.00**	**100.00**	**100.00**	**100.00**	**18.41**	**26.30**	**0.41**	**9.18**
Capital goods industry/manufacturing industry	**26.88**	**31.31**	**37.32**	**32.16**	**13.98**	**19.12**	**2.57**	**7.96**

Source: prepared by the author using data from the Foreign Trade Department (SECEX) of the Ministry of Development, Industry and Commerce (MDIC). Imports were converted into constant 1989 dollars on the basis of the United States producer price index (PPI).

equipment, while the shares of all other segments grew. In 2006, the segments with the greatest relative weight in Brazilian capital goods imports were basic electronics (15.7%), playback, recording and amplification devices (11.1%), motors, pumps, compressors and transmission equipment (9.7%) and aeronautical equipment (8.2%). Lastly, in 2006 exports and imports of pumps, motors, compressors and transmission equipment, and of other extraction machinery, recorded similar shares of capital goods exports and imports; this indicates that international trade flows in these segments are essentially intra-industry, i.e., they owe more to the search for greater economies of scale by Brazilian producers and their respective international partners than to relative price differences.

V

The Brazilian capital goods industry and the segments with the greatest growth potential

The Production Development Policy classes the capital goods industry as one of the sectors best placed to enhance the competitiveness and international trading position of Brazilian industry (MDIC, 2008). The goals of the PDP for 2007-2010 are ambitious. One of the main ones is to increase capital goods exports from US$ 19.6 billion to US$ 26.7 billion and raise private R&D expenditure from 1.32% to 2% of each firm's total net revenue.[44] To attain these goals, the PDP provides for a range of industrial policy instruments, including bndes innovation financing facilities,[45] accelerated depreciation for machinery and equipment that reduce production times for capital goods by 20% and the abolition of the 0.38% tax on financial transactions in the case of BNDES lending operations.[46]

Although the new support instruments may prove effective in raising the competitiveness of the capital goods industry, the PDP does not identify the segments with the greatest development potential. Since the industry comprises numerous segments that differ markedly in their structural and competitive profile, it is worth making an extra effort to identify those with the best prospects of increasing their competitiveness.

The set of indicators presented in this paper leads us to conclude that the Brazilian capital goods industry can be divided into four groups on the basis of structural characteristics, labour efficiency and international competitiveness. The first group comprises those segments whose production efficiency increased strongly in the recent period or that already have unmistakable competitive advantages: mining and construction machinery and equipment; agricultural machinery and equipment; telephony and radio-telephony equipment and television and radio transmitters; land motors, machinery and equipment; and aeronautical machinery and equipment.

The second group includes segments which have performed poorly in terms of labour efficiency improvements and currently lack comparative advantage, but are in a position to improve their competitiveness over the medium term, given their weight in the composition of capital goods exports: pumps, compressors and transmission equipment; generators, transmitters and electric motors.

The third group includes segments that require specific industrial and technological policies to drive their future development, and that face an enormous uphill struggle to become really efficient and internationally competitive. These are segments that figure quite substantially in the structure of the capital goods industry and are strategically important for economic development: electricity generating machinery and equipment and equipment for electronic data processing systems.

The fourth and last group includes traditional segments whose performance, in terms of production efficiency and international competitiveness, suffered from the succession of events that began in the 1990s, including relatively rapid trade liberalization in a context of high inflation, overvaluation of the Brazilian currency in real terms and low rates of growth in the economy. These are basically the segments in the traditional industrial machinery and equipment group, particularly metal frames and heavy boilers, tanks and boilers and machine tools.

Table 7 details the segments with the greatest growth potential, the reasons for classing them as such and certain support measures that could complement the industrial and technological policy instruments contained in the Production Development Policy.

[44] This is for mass-produced capital goods. For capital goods manufactured to order, the goal is to raise R&D spending from 0.55% to 0.8% over the same period.

[45] BNDES, the largest development bank in Latin America, is the main source of long-term financing for the Brazilian economy. Since its creation in 1952, it has traditionally financed machinery and equipment purchases and investment projects, but not innovation projects. Since 2006, however, the bank has introduced and diversified new operating lines oriented towards innovation projects.

[46] See MDIC (2008) for more on these instruments.

An earlier study (Nassif, 2003b, p. 60) recommended that "given the technological complexities and the efficient production scales required in some segments", it would be more advisable to carry on importing many of the goods produced by the capital goods industry. Furthermore, large technological gaps in most segments mean that PDP instruments will have to be applied much more carefully than in the past if they are to produce satisfactory results. The complementary measures proposed in this article are compatible with the PDP objectives of increasing competitiveness and expanding capital goods exports, as they concern the following:

(i) stimulating private-sector R&D;
(ii) improving efficiency to take greater advantage of economies of scale;
(iii) financing investment for sectoral expansion, modernization and restructuring;
(iv) coordinating foreign investment so that more technology is transferred and spread to Brazilian producers and production chains.

TABLE 7

Brazil (capital goods industry): segments with the greatest growth potential and measures that could supplement the Production Development Policy

Segment	Reasons why it has growth potential	Supplementary measures
	GROUP 1	
▶ Mining and construction machinery and equipment	Share of capital goods industry value added. Comparative advantage and strong export potential.	Work at government level to encourage greater linkage between producers and customers in a context of rising investment thanks to the Growth Acceleration Programme (PAC). Create new financial engineering tools to increase the number of firms supported by BNDES.
▶ Agricultural machinery and equipment	Substantial weight in the structure of the capital goods industry. High level of labour efficiency and international competitiveness. Strong export potential.	Work to expand the export base, which is still small.
▶ Telephony and radio-telephony equipment and television and radio transmitters	Comparative advantage. Considerable weight in the structure of the capital goods industry. Strong export potential.	Modify financing mechanisms to include requirements (not just the "basic production process" requirement) that induce local and foreign firms to increase private-sector R&D spending. Negotiate local R&D commitments and the use of instruments to promote technology spillovers among local firms and production chains as part of the mechanisms used to attract inward investment, following recent Asian experience.
▶ Road transport machinery and equipment	Very substantial weight in the structure of the capital goods industry. High level of labour efficiency and international competitiveness. Strong export potential.	Formulate promotional policies that spur greater economies of scale and a considerable increase in export values.
▶ Aeronautical machinery and equipment	As per road machinery and equipment.	Attract manufacturers of high-technology spares, parts and components for the Brazilian market (e.g., turbines and other components). Provide financial support for small and medium-sized producers of aeronautical components, for local production of equipment, spares and parts and for the provision of aeronautical services under the BNDES Pro-Aeronáutica programme. Maintain export financing mechanisms.

Table 7 continues overleaf

	GROUP 2	
▶ Motors, pumps, compressors and transmission equipment ▶ Generators, transmitters and electric motors	Considerable weight in the capital goods industry value added structure.	Use agreements with local firms to encourage them to export a growing share of output. Promote industrial and technological restructuring by attracting companies in the segment into the BNDES Programme for the Modernization of Machines and Equipment Installed in the Country (FINAME-MODERNIZA BK). Stimulate the development of engineering procurement consultancy firms to foster procurement of locally made equipment. Use government procurement policies (public tenders) to stimulate demand. As with the previous segment, encourage the formation of engineering procurement consultancy firms in the interests of local procurement.
	GROUP 3	
▶ Electricity generating machinery and equipment	Strong growth in potential demand for electricity generating machinery and equipment as a result of investments expected in the Brazilian energy sector. Reasonably substantial weight in the structure of the capital goods industry. Strategic segment for infrastructure and economic development.	Use government procurement policies (public tenders) as an instrument to stimulate demand in this segment. Coordinate with the sectors that are the end users of this equipment by means of mechanisms designed to stimulate orders for Brazilian-made electricity generating machinery and equipment.
▶ Equipment for electronic data processing systems ▶ Measuring, testing and control devices	Reasonably substantial weight in the structure of the capital goods industry. Strategic importance for infrastructure and economic development.	Modify financing mechanisms to include requirements (not just the "basic production process" requirement) that induce local and foreign firms to increase private-sector R&D spending. Negotiate local R&D commitments and the use of instruments to promote technology spillovers as part of the mechanisms used to attract foreign investment, following recent Asian experience.
	GROUP 4	
▶ Traditional industrial machinery and equipment, especially Metal frames and heavy boilers Tanks and boilers Machine tools	Sectors badly affected by adverse macroeconomic developments since the early 1990s.	Promote technological restructuring in the industry by attracting companies in the segment into the BNDES Programme for the Modernization of Machines and Equipment Installed in the Country (FINAME-MODERNIZA BK). In the case of machine tools, develop mechanisms to increase technology training in this segment.

Source: prepared by the author on the basis of Brazilian and international competitiveness indicators for the capital goods industry.

VI
Conclusion

This study set out to analyse the structural and competitive profile of the Brazilian capital goods industry. It has shown that this industry, which accounts for about 12% of total manufacturing industry value added, presents quite heterogeneous conditions of production efficiency and international competitiveness. The average annual decline of labour productivity in this industry between 1996 and 2005 (about -0.8%) was no greater than that for Brazilian manufacturing industry as a whole in the same period (-1%).

In view of different considerations –improvements in production efficiency and international competitiveness in this industry, its relative weight in the industrial structure, indeed its strategic importance to economic development– this article has sought to identify, justify and propose some measures which could complement the PDP and whose aim is to enhance the efficiency and competitiveness of those segments of the capital goods industry that have the greatest growth potential. None of the recommendations made entails a return to the overblown protection mechanisms of the import substitution period, since what is proposed are not market quotas and high tariff and non-tariff barriers to imports but, essentially, instruments to stimulate research, development and technological training and financial mechanisms for the industrial restructuring of sectors with development potential. It is always worth stressing that government support policies need to be accompanied by mechanisms for supervising firms in receipt of public-sector benefits so that as far as possible corporate featherbedding and rent seeking are avoided.

(Original: Portuguese)

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